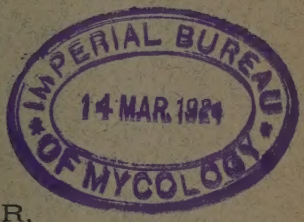
With Regards of
H. J. Webber

BULLETIN No. 13. V. P. P.—54.

U. S. DEPARTMENT OF AGRICULTURE.

DIVISION OF VEGETABLE PHYSIOLOGY AND PATHOLOGY.

SOOTY MOLD OF THE ORANGE AND ITS TREATMENT.



BY

HERBERT J. WEBBER,

ASSISTANT, DIVISION OF VEGETABLE PHYSIOLOGY AND PATHOLOGY.

[Issued June 17, 1897.]

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WASHINGTON:

GOVERNMENT PRINTING OFFICE.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF VEGETABLE PHYSIOLOGY AND PATHOLOGY,
Washington, D. C., March 25, 1897.

SIR: I have the honor to transmit herewith a report on sooty mold of the orange, by Mr. Herbert J. Webber, one of my assistants, and to recommend its publication as Bulletin No. 13 of this Division. When the work on citrous diseases was begun in 1892 urgent requests were made by orange growers that sooty mold be carefully studied, as it was causing an annual loss to the State estimated at $50,000. Mr. Webber was thus early led to a consideration of the matter, and his observations showed the urgency of the case and the necessity for careful experiments to determine the best methods of treatment. The work carried on at intervals during the past three years has been very satisfactory, resulting in the discovery of several effective remedies for the disease.

Respectfully,

B. T. GALLOWAY,
Chief of Division.

Hon. JAMES WILSON,
Secretary.

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SOOTY MOLD OF THE ORANGE AND ITS TREATMENT.

INTRODUCTION.

For a number of years sooty mold, a fungous disease of the orange and other citrous fruits, has caused considerable damage. Until recently, however, the injury done in any single grove was usually slight, and therefore little attention was given to the disease. In writing on the diseases of the orange in Florida five years ago Professor Underwood[1] mentioned this malady as of slight importance. Within the last few years, however, owing to the rapid spread of certain insect pests which the sooty mold follows, the disease has been assuming very serious proportions, and there is, therefore, great need of a successful treatment which may be used in combating it. Fifty thousand dollars may be considered a conservative estimate of the yearly damage caused by the disease.[2] At Citra, Gainesville, Panasoffkee, Ocala, Bartow, and other places throughout the orange regions of the State, whole groves are affected, and frequently hundreds of acres of trees in a single locality are literally black with the fungus.

DESCRIPTION OF SOOTY MOLD.

Sooty mold of the orange is a black fungus, of considerable botanical interest, belonging to the order Pyrenomycetes, and is probably to be referred to *Meliola penzigi* Sacc.[3] and *M. camelliæ* (Catt.) Sacc. The first account of this fungus was apparently given by Persoon[4] in 1822. He called it *Fumago citri*, but gave only a very brief description.

[1] Underwood, L. M., Diseases of the orange in Florida (Jour. of Mycol., 1891, Vol. III, p. 35.

[2] The severe freezes of last winter (December 29, 1894, and February 8, 1895) greatly injured the orange groves of Florida, defoliating practically all trees and killing many to the ground. The damage done by sooty mold this year (1895–96) will consequently be much less than previously. The discussion here given is based on conditions as they existed before the freezes referred to.

[3] M. A. Gaillard in his late monograph of the genus Meliola (Le Genre Meliola, Paris, 1892, p. 123), placed *M. camelliæ* (Catt.) Sacc. and *M. penzigi* Sacc. among the "Species excludendæ." The writer is in doubt as to the proper position of these fungi and has therefore followed the nomenclature of Saccardo (Sylloge Fungorum, Vol. I, pp. 62, 70), which, if not correct, will at least lead to no further confusion.

[4] Persoon, C. H., Mycologia Europæa, 1822, Vol. X.

Later Berkeley and Desmazières referred the fungus to Montagne's[1] genus Capnodium and described it under the name *Capnodium citri*.[2] In 1876 Dr. Farlow[3] described sooty mold in detail as it occurred on orange and olive leaves in California, and referred the fungus to *Capnodium citri* Berk. and Desm. He described several forms of reproductive bodies (the so-called conidia, pycnidia, and stylospores) in his specimens, but did not succeed in finding perithecia. It appears from the studies of Penzig[4] and Cattaneo[5] that *C. citri*, which was founded on an imperfect stage, should be referred to *Meliola penzigi* Sacc. and *M. camelliæ* (Catt.) Sacc. According to Penzig, sooty mold, or fumaggine, in Italy is caused sometimes by one and sometimes by the other of these fungi, and from their similarity he is inclined to think the two are identical.

In the writer's examination of sooty mold in Florida he has rarely found perithecia. Those observed were armed with rigid hairs (setulæ), thus apparently belonging to *Meliola camelliæ*, which differs from *M. penzigi* in having the perithecia armed. Furthermore, the ascospores in perithecia found here are destitute of longitudinal septa, thus agreeing with Cattaneo's description of *M. camelliæ*. It is probable that by more extended study it will be found that sooty mold in Florida is produced principally by both *M. penzigi* and *M. camelliæ*, or that these two fungi are identical, as Penzig has suggested.

The leaves and fruits of trees affected with this disease become covered with a black, velvety, membranous coating (fig. 1, old leaves). In slight attacks this coating covers only limited spots, but in severe cases the greater part of the upper surface of the leaves, fruits, and twigs are covered with a continuous membrane, so dense and thick that it may be removed from the leaf and torn up like paper. This membrane is made up of densely interwoven branched threads of mycelial filaments of the sooty mold fungus. The mycelium of sooty mold (fig. 1, old leaves, and fig. 6) when isolated varies in color from olive green to deep brown. In mass, as it occurs on the plant, it is a dark brown or black. In general size and appearance the cells of the mycelium vary greatly with age and conditions. In the comparatively young mycelium the cells are somewhat longer than broad, ranging from 8 to 20 micromillimeters[6] in length and from 6 to 10 micromillimeters in breadth. Frequently they become moniliform and nearly

[1] Montagne, Ann. de Sci. Nat., 1849, Vol. III, p. 11.

[2] Berkeley and Desmazières, On some molds referred by authors to Fumago, and on certain allied or analogous forms (Jour. Hort. Soc., London, 1849, Vol. IV, pp. 243–260; reprint pp. 1–19).

[3] Farlow, W. G., On a disease of olive and orange trees occurring in California in the spring and summer of 1875 (Bull. Bussey Inst., Vol. I, pp. 404–414).

[4] Penzig, O., Studi botanici sugli agrumi e sulle piante affini, Rome, 1887, pp. 319–322: also Funghi agrumicoli, Padova, 1882, p. 18.

[5] Cattaneo, A., Micet. agrum., p. 25.

[6] A micromillimeter is equal to about $\frac{1}{25000}$ of an inch.

isodiametric. The filaments often become more or less cemented together, forming a sort of false tissue. Adjacent cells also frequently send off branches, which anastomose, giving the filaments organic connection. Zoph[1] in his cultures of this fungus found the mycelium covered with a gelatinous sheath, which he believes cements the filaments together into a fungous mass and attaches this more firmly to the leaf of the plant on which it grows. This and the anastomosing of the filaments he thinks are the two factors which serve to hold the membrane so firmly together.

As nearly as can be determined, the fungus is entirely superficial on the leaf and is easily removed. Frequently the fungous membrane becomes detached at some point and is caught by the wind and torn off. These detached fragments are found scattered about in badly affected groves. By drying and stretching, the fungous membrane becomes partially detached and adheres only to the edges of the leaf, which are usually slightly rolled up, thus holding the membrane suspended over the face of the leaf. In this condition it is easily dislodged. Occasionally small knob-like projections occur on the cells of the mycelium, but no proof has been found that these penetrate the tissue of the leaf or in any way act as haustoria. Apparently they are merely organs of attachment. This conclusion has also been reached by Büsgen[2] and Farlow[3] in their studies. Large disks (hyphopodia) are also frequently developed, and these evidently serve as organs for attaching the fungus more firmly to the leaf.

The ways in which sooty mold is reproduced are so numerous and confusing that detailed descriptions of them will not be attempted in this bulletin. The principal reproducing agents are conidia, pycnidia, stylospores, and perithecia. Several forms of conidia are produced, some being but slight modifications of the common cells of the mycelium (fig. 7), while others are compound spores. The conidia are too small to be distinguished from the mycelium without the aid of a compound microscope. Pycnidia (fig. 3) are small, spherical, black reproductive bodies, about 40 micromillimeters (1/625 of an inch) in diameter, and are usually present in considerable numbers in the mycelium. They may be readily seen with a strong magnifying hand lens, but can not be definitely distinguished from perithecia or the young stages of the stylospores. Stylospores are borne in conceptacles, which in their simplest form resemble flasks with long drawn-out necks (fig. 4). Frequently, however, they are much branched (fig. 9, *d*), and as they project from 1 to 2 millimeters beyond the mycelium they form quite a conspicuous part of the fungus. They are easily recognized with the unaided eye, and can be seen with considerable distinctness with a hand lens.

[1] Zoph, Dr. W., Die Conidienfrüchte von Fumago (Nova Acta der Ksl. Leop. Carol. Deut. Akad. der Naturforscher, Vol. 40, p. 263).

[2] Büsgen, M., Der Honigtau: Biologische Studien an Pflanzen und Pflanzenläusen, pp. 66 and 67, Jena, 1891. Abdruck aus der Jen. Zeitsch. für Nat., No. 25).

[3] Farlow, W. G., l. c., p. 406.

Several sizes and forms of stylospore conceptacles are shown in fig. 9. Perithecia are black, spherical reproductive bodies (fig. 5), closely resembling pycnidia, from which they can not be distinguished with a hand lens. However, they are larger, being 80 millimeters (1/312 of an inch) in diameter. Each perithecium contains several asci[1] and each of these bears eight ascospores. Some of the investigators who have studied this disease have failed to find perithecia, and only twice has the writer found them in his examination of material from Florida.

The various reproductive bodies other than perithecia, particularly the conidia and stylospores, are developed in great abundance. These are easily carried from tree to tree or from grove to grove through the agency of the wind, or by birds, insects, or other animals. The wind, however, is by far the most active agent in spreading them.

NATURE OF SOOTY MOLD.

Sooty mold is not a parasitic fungus, as might at first be supposed. As Mayen[2], Büsgen[3], Farlow[4], and other investigators have concluded, it is probably a true saprophyte, drawing its nourishment entirely from the so-called honeydew (the sugary secretion exuded by certain scale insects). All investigations indicate that no nourishment is drawn directly from the plant. M. E. Guinier[5] lately published a paper claiming that under some conditions sweet fluids are exuded from the petiole and green twigs of the orange. He states that he has seen the fluid expelled as a fine mist or rain. If Guinier was correct in his observation this sweet fluid exuded as a mist would be caught on the stems and leaves below, and if it occurs commonly in orange groves it might serve to some extent as nourishment for the sooty mold. Considerable search has been made for similar exudations from orange trees in groves, but so far none have been found. In the case observed by Guinier it may have been caused, or at least greatly increased, by the abnormal conditions of the winter house in which the trees were growing.

DISTRIBUTION OF SOOTY MOLD.

Sooty mold is probably abundant throughout the orange regions of the world and is certainly quite destructive in Florida, Louisiana, and California. In 1875 Dr. Farlow[6] wrote: "From the general tenor of letters from California it is evident that the effect on the orange and olive crops has not been slightly, but markedly injurious." Later

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[1] Asci are spore sacks borne inside the perithecia.

[2] Mayen, F. J. F., Pflanzenpathologie, p. 187.

[3] Büsgen, l. c., pp. 66 and 67.

[4] Farlow, W. G., l. c., p. 406.

[5] Guinier, M. E., Sur l'émission d'un liquide sucré par les parties vertes de l'oranger (Compt. Rend., 1893, Vol. 116, pp. 1001, 1002; Review Bot. Centralbl., Vol. 56, p. 175).

[6] Farlow, W. G., l. c., p. 404.

investigations by the United States Department of Agriculture[1] showed sooty mold to be very abundant on the orange in California, principally following the black scale (*Lecanium oleæ*) and the cottony cushion scale (*Icerya purchasi*). In Louisiana Professor Morgan[2] reports sooty mold, following the mealy wing or white fly (*Aleyrodes citri*), as common from Baton Rouge to the Gulf of Mexico. Nurserymen are said to complain of the black or smutty condition of their plants caused by sooty mold. In Italy, where the disease is known as morfea, fumaggine, or nero, it is said by Penzig[3] to be abundant and troublesome. Berkeley and Desmazières[4] mentioned a severe epidemic of the sooty mold of orange trees in the Azores and Madeira Islands as early as 1849. In Germany, where the disease is known as Russthau,[5] it is reported as occurring commonly both in and out of hothouses. In Florida and Louisiana sooty mold is quite generally known as smut and black smut, but as the fungus causing the disease is not a smut fungus these terms are erroneous and their use should be discontinued.

PLANTS ON WHICH SOOTY MOLD OCCURS IN FLORIDA.

In Florida sooty mold occurs very abundantly throughout the State on certain wild plants. On the gall berry (*Ilex glabra*) it is very abundant, and follows the attacks of the wax scale. Frequently many acres of this plant are literally black with the fungus. On magnolia, Persea, palms, Andromeda, Laurus, smilax, persimmon, and many other wild plants sooty mold is widespread and frequently occurs, following various honeydew-secreting insects. The cultivated plants of Florida on which it is most abundant are the orange, lemon, and other citrous fruits, and pineapple, kaki, and cape jasmine. The reproductive bodies of the fungus are distributed everywhere in great numbers, and are usually present ready to spring up wherever suitable and sufficient nourishment is provided. This is true in orange groves as well as on uncultivated plants.

EFFECT OF SOOTY MOLD ON THE ORANGE TREE AND FRUIT.

The effect of sooty mold on the orange tree is very noticeable, the growth being usually greatly retarded and the blooming and fruiting light. In serious cases growth is frequently entirely checked, and blooming and fruiting wholly suppressed until relief is obtained. On diseased trees the effects of drought are also soon perceptible. The leaves wither quickly, and it has frequently been observed that they

[1] Ann. Rept. Commissioner of Agriculture, 1886, p. 482; Ann. Rept. Secretary of Agriculture, 1890, p. 251.

[2] Morgan, H. A., Scale insects of the orange (La. State Exp. Sta. Special Bull., 1893, p. 70).

[3] Penzig, O., l. c., p. 321.

[4] Berkeley and Desmazières, l. c., p. 244.

[5] Büsgen, l. c., p. 65; Schroeter, Dr. J., Die Pilze Schlesiens (Cohn's Cryptogamen-Flora von Schlesien, Vol. 3, p. 247).

curl and shrivel, as in the case of blighted trees, while the leaves of healthy trees in the same vicinity remain turgid and normal. The oranges on affected trees become covered with the black coating of the fungus when quite young. Frequently such oranges do not reach maturity, are usually smaller than those on healthy trees, and are dry and insipid, as they seldom form the normal amount of juice. They do not change to the normal bright orange color of mature ripe fruit till very late, and if the membrane of the sooty mold covering them is quite thick they partially retain their green color indefinitely.

The black fungus covering the oranges renders them unsightly and unsalable, and before being marketed they must be thoroughly washed. This process, besides necessitating a considerable expenditure of time and money, somewhat injures the keeping quality of the fruit, as shown by experiments made by growers, and even after washing much of it is unfit for market, being small and green.

The insects which sooty mold follows usually feed on the lower surface of the leaf, a habit probably due to the structure of the orange leaf, the tissue on the lower surface being softer and more porous and the elaborated food materials of the plant more accessible. Occasionally, however, they may be found on the young stems and upper surface of the leaves. The honeydew secreted by the insects on the young stems and lower surface of the leaves naturally falls principally on the upper surface of the leaves below, the exposed branches, and upper portions of the fruit (the basal portion, as the orange is always pendulous), and it is on these parts that the sooty mold grows.

When it is remembered that various investigators have shown that the process of phytosyntax[1] is almost entirely checked in a plant placed in the back part of a living room, opposite a window, where the light is fairly bright, but diffused, it can readily be judged that the effect of the dark, compact mycelial membrane of the sooty mold covering the leaves would be to almost wholly check the process of phytosyntax in the orange tree. Quite bright or direct sunlight is necessary for the best results. The injurious effects of sooty mold on the phytosyntax was clearly demonstrated by Büsgen.[2] He removed the fungous membrane from a small portion of a leaf and exposed the leaf to the sun. In the evening, after a sunny day, the leaf was plucked and the chlorophyll extracted with alcohol. After this the leaf was treated with iodine, and the parts from which the membrane had been removed in every case stained a dense blue, indicating the formation of an abundance of starch, while the surrounding portions of the leaf, which were protected from the sun by the fungous membrane, remained entirely uncolored, showing that no starch was formed. The stomata, or breathing pores, are also

[1] Phytosyntax is a term introduced by Prof. C. R. Barnes, in an article on the food of green plants (Bot. Gaz., 1893, XVIII, p. 409), to designate the process of formation of complex carbon compounds out of simple ones under the influence of light. This has heretofore been generally known under the ambiguous term "assimilation."

[2] Büsgen, l. c., p. 68.

to some extent closed by the sooty mold, and in this way the passage of gas is more or less hindered. In the orange leaf, however, the stomata are confined to the lower surface, where generally there is but little sooty mold. In plants where the stomata are on the upper surface of the leaf also, the damage resulting from the obstruction of the passage of gases would probably be considerably greater.

Dr. Berlese[1] has described the serious effect on oranges and lemons in Italy produced by sooty mold (fumaggine) following attacks of the mealy bug (*Dactylopius citri* Risso). The fruits produced are much smaller than normal ones and the production is sometimes entirely stopped. Frequently groves are reduced in a year to one-tenth of their usual productivity.

METHODS OF PREPARING FOR MARKET FRUITS AFFECTED WITH SOOTY MOLD.

Several methods of removing sooty mold from oranges are in general use. The following are descriptions of those most commonly employed: The oranges to be cleansed, together with sawdust and water, are placed in a common kerosene barrel holding about 50 gallons. To the center of each head of this barrel are attached iron pivots, which serve as axes. These axes fit into slots in standards, so that the barrel can be revolved by a crank attached to one of the pivots. The axis must not pass through the barrel, as it would bruise the oranges by hitting against them. On one side of the barrel a convenient-sized opening is made, which can be quickly and tightly closed by a water-tight covering. The barrel is closed and revolved for several minutes, or until the coating of sooty mold is removed. The fruit is then rinsed and spread on trays to dry. The kind of sawdust to be used in this operation is an important feature. Growers believe that in general crosscut sawdust is much better than the longitudinal, or that cut lengthwise, as it is freer from sharp ends, which are liable to pierce the rinds and thus injure the keeping quality of the fruit. Before using the sawdust many growers pass it through a coarse sieve, which removes the larger and longer fragments. If this is done it is claimed that it makes no difference what cut of sawdust is used. The sawdust used for this purpose is principally pine or cypress.

Some growers vary the above method of cleaning by carefully cushioning the interior of the barrel to prevent the bruising of the oranges and rolling them in dry sifted sawdust for several minutes. This removes the greater part of the sooty mold, gives the orange a gloss, and does not necessitate rinsing and drying. When this method is used the fruit is picked out of the mass of sawdust and passed directly to the sizer and then to the packers, the handling serving to sufficiently remove the adhering sawdust. In this process of cleaning the sawdust

[1] Berlese, Antonio, Le cocciniglie italiane viventi sugli agrumi (Rivista di Patologia Vegetale, 1893, Vol. 2, p. 173).

requires to be frequently changed. Some growers claim that this dry method is superior to the water and sawdust method. Again, many growers do all the washing by hand, claiming that this is the only way by which the sooty mold can be thoroughly removed. In this they are undoubtedly correct, though oranges properly cleaned by either of the above-described methods are quite creditable. In hand-washing each orange is scrubbed with a rag until clean. In this method soap is frequently used in the water. In regard to all methods of cleaning the orange, it may be said that they are very tedious and costly, and even after the most thorough cleansing the oranges are inferior in appearance and quality. As it frequently happens that hundreds of acres of fruit are literally covered with the fungus, some idea can be formed of the work necessary to cleanse it.

ORANGE INSECTS WHICH SOOTY MOLD FOLLOWS.

From the nature of the sooty mold it is evident that it becomes serious only as the insect pest which it follows spreads and becomes abundant. The quantity of sooty mold depends directly on the quantity of honeydew supplied. In Florida the following insects, which feed on the orange and lemon and secrete honeydew in considerable abundance, are commonly followed by the sooty mold: The mealy wing, or white fly (*Aleyrodes citri* R. and H.), wax scale (*Ceroplastes floridensis* Comstock), several naked scales (*Lecanium*), mealy bug (*Dactylodius citri* Risso), and orange aphis, or plant louse (*Aphis gossypii* Glover). Up to the present time in Florida the sooty mold becomes very serious only where it follows the attacks of the mealy wing, or white fly, and the main part of the discussion given here is based on studies of the disease in this connection.

The mealy wing, or white fly,[1] passes the winter in the mature larval stage, in which condition it forms thin, elliptical or ovate, transparent scales on the lower surface of the leaves. In early spring they pass into the pupal stage, which differs but slightly from the mature larvæ, and finally about the middle of March the adult insects begin to appear and continue to develop till about the first of April. The mature mealy wing is a minute, chalky, or mealy white, gnat-like insect, provided with four wings. The eggs deposited by this brood of adults require about three weeks for their development, and hatch into the larvæ principally between the middle of April and the first of May. The larvæ and pupæ continue their development through May and until about the first or middle of June, when the adults of the second brood begin to appear. The transformation of the second brood probably continues till the first or middle of July. The eggs of this brood hatch into the larval stage about the first of August and continue to

[1] In Insect Life, Vol. V, p. 219, Riley and Howard give descriptions and figures of the different stages of *Aleyrodes citri*, with many notes on their general habits. The reader is referred to their work for particulars not given here.

develop during the month. Most of August and part of September is usually consumed in the development of the larvæ and pupæ, the adults of the third brood appearing probably in greatest numbers about the middle of September or the first of October. The third brood of adults is the last in the season. Their eggs hatch into the larvæ about the last of October, and this stage, after developing to a mature form, continues during the winter. In the adult larval and pupal stages the mealy wing expels honeydew in considerable abundance, which, as explained above, supplies nourishment for the growth of the sooty mold.

METHODS OF TREATING TREES AFFECTED WITH SOOTY MOLD.

SPRAYING EXPERIMENTS.

In the investigation of sooty mold various spraying and fumigation experiments have been made, some of which have given very satisfactory results. Fifteen different sprays, of three to four strengths each, were experimented with at Gainesville during February and the early part of March, 1895. Three series of experiments, which may be designated as twig, branch, and plat sprayings, were conducted with each spray. In the twig sprayings twigs about 1½ feet long were carefully selected and immersed in the spray for a moment to insure thorough wetting. In the branch sprayings branches with a spread of from 4 to 5 feet were carefully selected and sprayed with a hand pump, the applications being made by the writer to insure thoroughness. In the plat sprayings the liquid was applied to groups of twenty-five trees each by a spray-pump outfit running two streams. In the last-named sprayings the work was done by hired colored laborers, who were merely instructed to spray thoroughly, and was designed as a check on conclusions drawn from too thorough spraying. In these experiments resin wash, pyrethro kerosene emulsion, and resin wash with tobacco decoction gave very satisfactory results. Kerosene emulsion, which has been recommended for sooty mold, did not give very favorable results. The effectiveness of the resin washes in general, however, was clearly demonstrated, and these are much cheaper and more convenient to use than any of the other sprays which were found to be effective. Experiments since conducted by the writer have been largely with various resin washes.

Later in the season (April 25) a second series of spraying tests were made at Gainesville, using resin wash and resin compound, each in several different strengths. About half a day after the completion of these experiments a heavy rain fell, and this probably greatly injured their effectiveness, as all resin washes are easily removed by rains. Notwithstanding the rain the resin wash gave very fair results. The resin compound, which had not been used before in this series of experiments, proved as effective as the resin wash, but neither spray was

sufficiently effective to be satisfactory, owing probably to the effect of the rain.

On August 1, 1894, another series of experiments was made at Ocala. Both the resin wash and resin compound proved fairly effective, but unfortunately the experiments were again injured by rain, which fell about a day after the sprays were applied.

On June 7, 1895, experiments were made at Myers in which the resin wash was again tried in several strengths in comparison with resin compound and proved very satisfactory.

EFFECTIVE SPRAYS.

Resin wash.—In all experiments made with resin wash for sooty mold uniformly good results were obtained, except in cases where the sprayings were followed by rains, and it can therefore be recommended as a very effective remedy for this malady. The formula for preparing resin wash[1] is as follows, the strength given being the one found most effective in treating the sooty mold when following the mealy wing, or white fly:

Resin	pounds	20
Caustic soda (98 per cent)	pounds	4
Fish oil (crude)	pints	3
Water to make	gallons	15

In preparing the resin wash place the resin, caustic soda, and fish oil in a large kettle. Pour over them 13 gallons of water, and boil until the resin is thoroughly dissolved, which requires from three to ten minutes after boiling has commenced. While hot add enough water to make just 15 gallons. This can be most readily accomplished by taking a tight keg or other tall receptacle, measuring into it 15 gallons of water, and plainly and permanently marking the height to which the 15 gallons reach. After boiling, the hot solution may be poured directly into this measuring keg and sufficient water added to bring it up to the 15-gallon mark. This serves as a stock preparation. When this stock preparation cools a fine yellowish precipitate forms and settles to the bottom of the vessel. The preparation must, therefore, be thoroughly stirred each time before measuring out to dilute, so as to

[1] The preparation of resin wash according to the directions which were given previous to the commencement of our experiments, was long and tedious, the necessary time of boiling being given at from one to three hours. Finding it the most effective remedy in treating sooty mold, the writer was led to experiment in the preparation of the wash, hoping to reduce the time required to prepare it. Experiments with 98 per cent caustic soda (70 per cent being the grade usually used) showed that a wash of equivalent strength could be made in a few minutes. This method of preparation was first published in the Daily Florida Citizen, April 12, 1894. It has since been published in Circular No. 15 of the Division of Vegetable Physiology and Pathology, U. S. Department of Agriculture, on the sooty mold of the orange, and has been referred to by Mr. B. T. Galloway (Insect Life, Vol. VII, p. 129) and by Mr. Marlatt (Insect Life, Vol. VII, p. 124).

uniformly mix this precipitate with the clear, dark amber-brown liquid, which forms by far the larger part of the stock preparation. An instrument like a churn dasher without perforations greatly facilitates rapid and thorough mixing.

When desired for use take 1 part of the stock preparation to 9 parts of water. If the wash is desired for immediate use, the materials, after boiling and while still hot, may be poured directly into the spray tank and diluted with cold water up to 150 gallons. This requires the addition of about 135 gallons of water.

If a perfectly fluid stock solution is preferred, the wash may be prepared as follows: Place the same proportions of resin, caustic soda, and fish oil in the kettle and pour over them from 15 to 17 gallons of water. Boil until the resin is thoroughly dissolved, and while the solution is still very hot dilute with cold water to exactly 21 gallons. To get this quantity the barrel may be prepared and marked in the manner described above. The resulting solution will be clear, dark amber-brown, and at ordinary Florida temperatures[1] will remain perfectly fluid. When ready to use dilute the whole formula to 150 gallons, or use in the proportion of 1 part of the stock solution to 6 parts of water.

Experiments have shown that where sooty mold follows the attacks of soft scales, such as the turtle-back scale (*Lecanium hesperidium*) or wax scale (*Ceroplastes floridensis*), resin wash or kerosene emulsion will be found effective; where it follows the mealy bug, resin wash and resin compound will give good results; and where it follows the aphis, or plant louse, resin compound, diluted in the proportion of 1 part of the stock solution to 9 parts water, can be recommended.

The cost of the materials for the resin wash as described above, based on prices quoted by Jacksonville and New York firms, will be less than one-third of a cent per gallon of the solution when diluted ready for application. When the expense of freight and labor in preparation is added, the cost will probably only slightly exceed one-third of a cent per gallon. The materials for the wash may be procured from any wholesale drug firm or dealer in agricultural chemicals. Resin is put up in barrels of about 275 pounds each, and varies in price from $1 to $1.50 per barrel. Crude resin answers the purpose as well as the refined. The 98 per cent caustic soda, which is a white substance similar in appearance to granulated sugar, has been used because of the greater ease in handling. It can be purchased by the barrel (containing about 450 pounds) for from 5¼ to 5½ cents per pound. In 100 and 200 pound packages it will cost about 6½ or 7 cents per pound. In the case of the majority of growers it is probably best to purchase rather small packages, as the material when exposed to the air absorbs moisture and is rendered unfit for use. A keg or barrel of caustic

[1] In cool winter weather a precipitate may form in this as in the formula given above, but in ordinary spring, summer, and fall temperatures it remains perfectly fluid. If a precipitate once forms it will not be redissolved until again heated.

soda when once opened must be closed again if all is not desired for immediate use. The crude fish oil costs in New York or Philadelphia from 30 to 45 cents per gallon. At the rates above quoted the materials necessary for the resin-wash formula will cost 45 cents for each 150 gallons of the wash.

It has been feared by some orange growers that the caustic soda in the resin wash would injure the fruit. There is no danger from this source, however, as the wash has been extensively used in California for a number of years, and we are assured that no injurious effects have been noticed. It was also applied during the summers of 1894 and 1895 in numerous groves in Florida, and so far as could be observed the fruit was as acid and pleasant to the taste as usual. Of course, if the wash is used too strong the fruit may be burned, but unless it is used fully twice the strength here recommended no injuries will result.

Resin compound.—The resin compound has not been as thoroughly tested as the resin wash, but in several cases where used in connection with resin wash it gave fully as satisfactory results, and the writer believes that this also may be safely recommended for sooty mold. The following is the formula for resin compound,[1] the strength recommended being, as in the case of the resin wash, the one found most effective for sooty mold when following mealy wing:

Resin	pounds..	8
Sal soda, crystalline, or 2 pounds of efflouresced or powdered material, pounds		4
Water to make	gallons..	5

Place the resin and sal soda in a comparatively large kettle with 1 quart of water. Boil, meanwhile stirring briskly, until the resin and sal soda are thoroughly melted together and form a frothy mixture without lumps. Now add 4 gallons of cold water, pouring it in slowly and discontinuing at short intervals to avoid chilling the mixture too suddenly. When all the water has been added, bring the mixture to a boil; while still hot pour out into a measuring keg, as in the case of the resin wash, and add sufficient cold water to make 5 gallons. If correctly made, the solution will be thick and sirupy, of a dark brown color, and translucent, and may be preserved as a stock solution. When ready to use, dilute in the proportion of 1 part of the stock solution to 7 parts of water.

If the wash is desired for immediate use, the materials, after boiling and while still hot, may be poured directly into the spray tank and diluted with cold water up to 40 gallons. The resin compound, when diluted ready for application, forms a dirty brownish white mixture. Mixing the ingredients according to the above directions usually

[1] The formula here given for resin compound differs somewhat in the proportions of the ingredients and in the method of preparation from that which is usually given. It will be found somewhat simpler, and requires less time in its preparation.

requires about twenty-five minutes, but much time may be saved by mixing a larger quantity at once.

When exposed to the air the crystalline sal soda used in preparing the resin compound easily loses a large portion of the water of crystallization and crumbles to a white powder. Several cases are known to the writer where sal soda which had effloresced by unavoidable exposure was discarded by orange growers as worthless, thus resulting in considerable loss. The strength of the material which had effloresced by exposure to the air varies considerably,[1] but from the results of several experiments the writer thinks that a resin compound of comparatively the same strength and physical properties can be made by using the effloresced or powdered material, changing the above formula to 8 pounds of resin, 2 pounds of effloresced or powdered sal soda, and 5 gallons of water. Where the crystalline sal soda is used, the wash should be made and diluted for use according to the directions given for the resin compound.

The materials for preparing the resin compound, based on estimates as above, cost only about one-fifth of a cent per gallon when the solution is diluted ready for application. The materials for preparing this wash may be procured in small quantities in any town from a druggist or grocer, but retail prices are so high as to render the spray too expensive to use extensively. The crystalline sal soda may be obtained in New York by the barrel (containing 350 pounds) at about 1 cent per pound, and in kegs (containing 140 pounds) at about $1\frac{1}{10}$ cents per pound. The materials for preparing the resin compound, it will be seen, are much cheaper than those for preparing the same amount of resin wash. The labor in making the resin compound is somewhat greater than in making the resin wash, but the difference is so slight as to be hardly worth taking into consideration. The writer thinks there can be little doubt that the resin compound of the strength recommended is as effective as the resin wash, so that from the standpoint of economy the resin compound would seem to be the most satisfactory remedy.

WHEN TO SPRAY.

In the treatment of sooty mold it is very important to understand when to apply the sprays. The fungus, as shown above, is probably wholly of saprophytic habit, deriving its nourishment from the honeydew secreted by the insects which it invariably follows. The most

[1] As in the crystalline sal soda ($Na_2CO_3 10H_2O$) the water of crystallization makes up considerably more than half the weight of the molecule, it is probable that taking one-half of the weight which is used of the crystalline material will allow for sufficient water remaining, so that the strength of the spray will be comparatively the same. If sufficient water has not been given off to reduce the sal soda to one-half of its original weight, it will be readily seen that the strength of the spray will be lessened. If, on the other hand, all the water of crystallization has been given off, the strength of the spray will be increased.

practical way to treat the fungus, therefore, is to destroy the insect which supplies its nourishment. As the fungus becomes serious in Florida only when following the mealy wing, or white fly (*Aleyrodes citri*), the directions given here for the treatment of the malady are based on its occurrence in connection with this insect. The experiments which have been conducted indicate that the mealy wing is most easily affected by sprays when in the larval or pupal stage, and it is therefore best to make the sprayings when the majority of the insects are in one of these stages.

In groves badly infected with sooty mold three successive applications should be made some time between December and the middle of March. It is important that they should be completed by March 10, or before the adult mealy wings begin to appear. It is best not to spray the trees until the fruit is removed, and as the latter part of the season is as satisfactory for treatment as the early part, the sprayings can be deferred until then without detriment. A second period for spraying the trees, should sooty mold be abundant, is during the month of May. In badly infected groves it is very important that at least one thorough application be made during this period. Three sprayings during the winter period and one during the May period, if thoroughly made, will prove an effective treatment. If only three applications can be made, two of these would best be made during the winter period and one during the May period. One application during the May period has been found by orange growers working on an extensive scale to be very necessary. A third period, when the majority of the mealy wings are in the larval and pupal stages, is during August and the early part of September. If an examination of the grove should indicate that the sooty mold is spreading onto the fruit, it may be desirable to make one application during this period to insure bright fruit. This will probably not be necessary if the sprayings recommended during the first two periods have been thoroughly made. These spraying periods may vary considerably, depending upon the condition of the mealy wing. The spraying should be done when the majority of them are in the larval stage. The winter and May spraying periods are in general the best times for the treatment of this malady, as during these periods the rainfall is usually slight. The resin sprays are easily removed by rains, and this renders their use during the summer spraying period rather precarious. Care must be taken not to spray while it is raining or when it is probable that rain will fall within two or three days.

HOW TO SPRAY.

Too much emphasis can not be placed on the necessity of spraying correctly for the sooty mold. As the larvæ and pupæ of the mealy wing, the insect which the sooty mold usually follows, almost exclusively infest the lower surface of the leaves, the spray must be directed so as to strike this surface. If the operator stands off from the tree and merely directs the spray upon it only the upper surface of the

foliage is wetted. He must get beneath the tree and direct the spray upward and outward, as in this way the lower surface can best be reached. Most of the spray should be applied from this position. For personal comfort the tree should be sprayed first from the trunk outward, the operator gradually moving around the tree until all parts are reached. The tree should then be sprayed from the outside, but this exterior treatment need not be so thorough. In spraying small trees the nozzle may be held within the foliage near the trunk, so that the spray may be directed outward. In this way the opposite side can be sprayed without rendering it necessary for the operator to get under the tree.

As the foliage of the orange tree is usually very dense, it requires considerable of the spray to reach every leaf. The spray should not be spared, however, as in order to be effective every leaf must be thoroughly wetted, at least on the lower surface. Usually from 15 to 20 gallons will suffice to spray a fourteen-year-old tree, but the writer has found many of the leaves of a seedling orange tree 25 feet high perfectly dry on the lower surface even after 25 gallons of the spray had been applied.

Before beginning treatment for sooty mold it is a good practice to trim up the trees within around the trunk and main limbs. This leaves most of the foliage near the exterior of the tree and greatly facilitates spraying. All branches pruned off should be burned. When trees are trimmed in this manner numerous water sprouts spring up. These should be allowed to grow between the spraying periods, but regularly in the early part of each of these periods they should be pruned off and burned. This practice, it is believed, will be found of great secondary aid in combating the malady, owing to the fact that the mealy wing larvæ collect on the sprouts in great numbers and are thus destroyed. A few of the orange growers of the State have followed this practice regularly for several years, with apparently good results. Even if the spraying treatments are limited to the winter period, which is probably advisable, it will be well to continue regularly to prune and burn the water sprouts at the beginning of each spraying period.

FUMIGATION.[1]

Quite thorough tests have been made in the treatment of sooty mold by fumigation with hydrocyanic acid gas. These tests have clearly demonstrated that fumigation is effective and may be recommended as a successful treatment for the malady. The gas treatment has the advantage of reaching all portions of the tree, and a single treatment is thus far more effective than a single spraying. One treatment

[1]Numerous descriptions of the methods of fumigation have appeared in the publications of the United States Department of Agriculture, prepared mostly by Mr. D. W. Coquillett. The following are the principal references: Ann. Repts., 1887, pp. 123–142; 1890, pp. 123–126; 1891, pp. 163–166; Insect Life, Vol. I, pp. 41, 42, 286; Vol. II, pp. 202–207; Vol. III, pp. 457–460; Vol. IV, pp. 46, 47, 328; Vol. VI, pp. 176–180; and Division of Entomology Bull. No. 23, pp. 20–27.

during the year, if properly made, should be sufficient. If fumigation is used the treatment should be made some time between December and the first of March. At this season the temperature is low, a feature of importance in fumigation, as the trees are more liable to be injured if the temperature is high.

Fumigation may be accomplished by placing over the tree a tent of some closely woven material, as 8 ounce duck or drilling. This should be oiled and painted black if the treatment is to be made in daylight. The edges of the tent are held down by a few shovelfuls of earth. For generating the gas, fused 98 per cent potassium cyanide, commercial sulphuric acid, and water are used, in the proportion of 1 ounce (avoirdupois) of potassium cyanide to 1 fluid ounce of sulphuric acid and 2 fluid ounces of water. To give the proper concentration of gas the quantities to be used vary somewhat with the size of the tree. It is estimated that each 180 cubic feet of space inclosed in the tent will require about 1 ounce of potassium cyanide and the other materials in proportion.[1] The water and sulphuric acid are placed together in an earthen vessel in the order named,[2] and the vessel is placed under the tent. The potassium cyanide is then dropped in and the operator quickly withdraws from the tent and closes the opening. In treating sooty mold it has been found more effective to allow the gas to act slightly longer than is customary. Good results have been obtained from forty-minute treatments.

To avoid loss of time from four to six tents should be used. In this way the tent can be removed from the first tree treated by the time the last tent is set up. Care must be exercised in applying this method of treatment, as the potassium cyanide and the gas generated are poisonous.

ENTOMOGENOUS FUNGI AS AN AID IN COMBATING SOOTY MOLD.

MEALY WING ASCHERSONIA (ASCHERSONIA ALEYRODIS WEBBER N. SP.).

In the course of the sooty mold investigations several fungous parasites have been found, which it is believed will be of great assistance in combating the malady, from the fact that they attack the honeydew-secreting insects.

In August, 1893, the writer collected in the grove of Mr. J. H. Harp, of Crescent City, Fla., some orange leaves infested with the larvæ and pupæ of the mealy wing, or white fly (*Aleyrodes citri*). Mixed with the insects on the same leaves the highly colored pustules of a fungus were noticed (fig. 2), but nothing was thought of the significance of the discovery at the time. In January, 1894, the writer visited the orange grove of Mr. W. B. Varn, of Bartow, Fla., which was badly infected with

[1] Convenient tables showing the proportions to use for various sizes of trees, are given by Mr. D. E. Coquillett in Division of Entomology Bull. No. 23, p. 26.

[2] To avoid explosions, the sulphuric acid should always be poured slowly upon the water instead of pouring the water on the sulphuric acid.

the sooty mold following the mealy wing, and found the fungus in great abundance. A more careful examination of this material led to the conclusion that the fungus was probably a parasite on the larvæ and pupæ of the mealy wing. Numerous groves where the fungus infests the mealy wing have since been examined, particularly in the vicinity of Crescent City, Gainesville, Myers, and Manatee, Fla. It is also known to occur to some extent at Citra and to be very abundant in groves at Panasoffkee. Shortly after the fungus was discovered in 1893 no trace of it could be found in the groves at Citra. Since that time, however, it has appeared there and spread very rapidly. It was reported by growers to be quite abundant in certain localities at the time of the first freeze (December 28, 1894).

The results of the preliminary examination of this fungus were published in the Journal of Mycology in 1894, where the fungus was provisionally referred to *Aschersonia tahitensis* Mont.[1] This name was used again later in a short account of the sooty mold in a bulletin on the principal diseases of citrous fruits in Florida.[2] A further study of the fungus, however, rendered it doubtful whether this determination was correct, and specimens were sent to Dr. N. Patouillard, of Paris, to be compared with Montagne's original specimens of *Aschersonia tahitensis*. After comparing the two fungi, Dr. Patouillard pronounced the mealy wing Aschersonia to be entirely distinct.[3] As this fungus seems to be distinct from all described species, the writer has named it *Aschersonia aleyrodis*.[4]

The mealy wing Aschersonia is closely related to *Aschersonia tahi-*

[1] Webber, Herbert J., Preliminary notice of a fungous parasite on *Aleyrodes citri* R. & H. (Jour. of Mycol., Vol. VII, p. 363).

[2] Swingle, Walter T., and Webber, Herbert J., The principal diseases of citrous fruits in Florida (Div. Veg. Physiology and Pathology Bull. No. 8, 1896, p. 27).

[3] Under date of September 7, 1896, Dr. Patouillard wrote as follows: "Ce sont deux plantes bien distinctes. *A. tahitensis* a le stroma *jaune de chrome*, hémisphérique, dépourvu d'hypothalle mucédinéen, moitié plus petit que dans votre espèce; les périthèces sont également plus petits, leur contenu est verdâtre (et non orangé-rouge); les spores sont très distinctement munies de gouttelettes brillantes. De plus les stromes sont épiphylles. Il y a des paraphyses comme dans votre plante. En conséquence je pense qu'il est nécessaire de distinguer les deux champignons. J'ai également comparé vos spécimens avec d'autre Aschersonia et ne peut arriver à une assimilation exact; il serait bon de séparer comme espèce distincte la plante de l'oranger."

[4] *Aschersonia aleyrodis* n. sp.: Stroma hypophyllous, depressed hemispherical, pinkish buff or cream colored, coriaceous, 1–2½ mm. in diameter; mycelial hypothallus grayish white, forming a thin membrane closely adhering to the leaf and extending about 1 mm. beyond the stroma; perithecia membranaceous, at first superficial, later becoming immersed, irregular, reniform or orbicular in mature specimens, and opening by small, round, or elliptical pores or slits; basidia crowded, filiform, slender, continuous, 28–40 μ long, 0.94–1.5 μ in diameter; paraphyses abundant, slender, projecting beyond the basidia, 65–100 μ long, ¾–1 μ in diameter; sporules fusiform, continuous, mucilaginous, hyaline, sometimes obscurely 3–4 guttulate, 9.4–14.1 μ long by 0.94–1.88 μ wide, very abundant and erumpent, forming conspicuous coral red or rufus masses. (Parasitic on *Aleyrodes citri* R. & H. infesting citrous leaves in Florida.)

tensis Mont.[1] It is hypophyllous, while *A. tahitensis* is epiphyllous. The stroma is larger and usually has a distinct mycelial hypothallus, or basal micelium, which, according to Patouillard, is not present in *A. tahitensis*. The perithecia are at first superficial, but by the growth of the stroma become gradually immersed (fig. 10). They finally become kidney-shaped, opening above by small, round pores or slits (fig. 11). In *A. tahitensis* the perithecia are smaller and longer, being ovoid and compressed laterally instead of parallel to the surface, as in *A. aleyrodis*. The basidia, which are crowded together, forming a dense, compact layer (fig. 15), are longer than in *A. tahitensis*. The sporules are produced in enormous numbers and are mucilaginous, being held together in large masses, which are erumpent, projecting frequently one-half millimeter above the stroma (fig. 10). On leaves protected from rain and dew they sometimes project from 1½ to 2 millimeters (fig. 22). They are coral red or rufus and very conspicuous, while in *A. tahitensis*, according to Patouillard, they are greenish. In *A. tahitensis*, furthermore, the sporules are very distinctly guttulate, while in the mealy wing Aschersonia, mounted in glycerin or water, they only occasionally appear to be guttulate (figs. 14 and 16). The paraphyses, which are quite evident in the mealy wing Aschersonia, are not mentioned by Montagne as occurring in *A. tahitensis*. They are, however, said by Patouillard to be present. Peculiar darkened cells occur at irregular intervals in the paraphyses of the mealy wing Aschersonia, which are quite characteristic (fig. 15).

The mealy wing Aschersonia has been found infecting mealy wing larvæ (*Aleyrodes citri*) on the common orange (*Citrus aurantium*), pomelo (*C. decumana*), mandarin (*C. nobilis*), lemon (*C. limonum*), and sour orange (*C. bigaradia*). The fungus may, of course, occur on any plant subject to attacks of the mealy wing.

Previous to the publication of his preliminary note in Journal of Mycology, the writer is not aware that Aschersonia was known to be parasitic on insects. Four other species of Aschersonia parasitic on scale insects have been discovered in the course of the investigations of the writer on sooty mold, and these will be mentioned in detail below. This seems to strongly indicate the general entomogenous

[1] For comparison, Montagne's original description is given as follows: *Aschersonia taitensis* Montag. mss.: Stromate hemisphærico truncato obtuso luteo, peritheciis subquindenis erectis minutis, poris per rimulas extus conjunctis (Hab. in pagina superiori foliorum Cyrtandræ cujusdam taitensis lecta, Coll. Mus. Par. Parasit., No. 25).

Desc.—Sparsa, epiphylla. Stroma hemisphæricum, basi byssino-membranacea expansum, luteum, ætate provectiori vaccinum, intus concolor, 1 ad 2 millim. diametro metiens, semillimimetrum altum. Perithecia stromati prorsus immersa, ovoidea, in collum brevissimum attenuata, erecta, ½ millim. longa, apice poro sensim ampliante pertusa. Basidia filiformia, tenuissima, 20 ad 25 millimillim. longa, primitus sporas sustinentia. Sporæ tandem innumeræ, mucilaginis ope erumpentes, minutissimæ, fusiformes, utroque fine acutissimæ, 15 millimillim. longæ, vix 2 millimillim. in medio crassæ, hyalinæ sporulas quaternas intervallis manifestis sejunctas includentes (Montagne, in Sixième centurie de plantes cellulaires exotiques Nouvelles, Ann. d. Sci. Nat., ser. 3, T. X, 1848, p. 122).

nature of the fungi of this genus. Dr. Patouillard informs me that he has frequently found the different Aschersonias which he has studied associated with larval follicles similar to those of *Aleyrodes citri*. The Aschersonias appear to be obligate parasites in the early stages of development, but continue their development for some time after the death of the insect, absorbing almost the entire body. They would thus seem in their later stages to be what De Bary terms facultative saprophytes.[1] The case of Cordyceps, which De Bary[2] has pointed out as being saprophytic in the later stages of development, seems analogous to what we have here.

Development of mealy wing Aschersonia.—Apparently the mealy wing Aschersonia (*A. aleyrodis*) attacks the mealy wing only in the larval and pupal stages. The infection probably takes place most abundantly while the larvæ are young. The mature larvæ and pupæ are, however, frequently attacked. At Myers, Fla., June 6, 1895, the writer found Aschersonia very abundant in the early stages of development. Most of the larvæ were just approaching maturity. It was at that time almost impossible to find good mature specimens of the Aschersonia, the pustules which developed on the preceding brood of larvæ, which matured in March, having become old and weatherworn. The first indication of the effect of the fungus on the larva of the mealy wing as observed by the writer, is the appearance of slightly opaque, yellowish spots usually near the edge of the larva. In the early stages of infection the larva becomes noticeably swollen and appears to secrete a greater abundance of honeydew than normally. It is probable, however, that owing to the weakened condition of the larva the honeydew is not expelled with sufficient force so that as it is slowly discharged it collects about the insect, and this would make it appear that there is an excessive amount. This condition gives rise to another character of some interest. The honeydew collected around the infected insects furnishes nourishment for the sooty mold, which frequently springs up and makes a conspicuous growth. The growth of the sooty mold is more rapid than that of Aschersonia, so that it sometimes happens that a rank growth of the sooty mold smothers both the insect and the Aschersonia. It is very common to find a circle of the sooty mold surrounding the Aschersonia pustules. Where Aschersonia becomes abundant the leaves almost always have considerable sooty mold mixed in around the Aschersonia pustules, while in case no Aschersonia develops the sooty mold does not appear.[3]

[1] De Bary, Vergleichende Morphologie und Biologie der Pilze, Mycetozoen, und Bacterien, p. 382.

[2] De Bary, l. c., p. 401.

[3] The forcible expulsion of the honeydew by the mealy wing and other honeydew-secreting insects would seem to be a protective character, as the collection of the honeydew around the insect results in a luxuriant growth of the sooty mold and other saprophytic fungi which would probably prove fatal to their further development. When the mealy wing larva locates on the upper surface of the leaf, as it sometimes does, it is usually killed by the sooty mold developing over it.

As the Aschersonia develops the interior organs of the larva appear to contract away from the margin, leaving a narrow circle, which becomes filled with hyphæ. This circle becomes opaque and whitish, presenting a very characteristic appearance (fig. 18, compare with healthy larva, fig. 17). Shortly after this the hyphæ burst out around the edge of the larva, forming a dense marginal fringe. This may form all around the larva at about the same time, or develop at one portion of the margin sooner than at the others (figs. 19 and 20). The body of the larva at this time is plainly visible, but it is opaque and yellowish throughout. Death usually ensues, the writer believes, before the hyphæ burst out. The fungus does not spread over the leaf to any extent, but grows upward in a mass, gradually spreading over the larval scale. It is not uncommon to find the perithecia, with their bright coral red masses of sporules, formed in a circle around the edge of the larva while it is yet visible (fig. 20). As the Aschersonia develops the hyphæ spread over the larva, forming a dense, compact stroma, which ultimately entirely envelops the larva (figs. 2, 10, 11, and 21–23). The stroma in this stage is thin and disk-like, the fructification being usually borne in a circle near the edge. The hymenium at this time is spread out on the surface of the stroma or but slightly sunken, the sporules projecting in a conical coral red or rufus mass (fig. 10). As the fungus develops the stroma becomes thickened and hemispherical, and the hymenium gradually becomes immersed (figs. 11 and 23). The hyphæ, which make up the main mass of the stroma, are from 3.5 to 7.5 micromillimeters in diameter. Within the body of the insect and near the perithecia they are somewhat smaller. They are very tortuous or flexuous and are intricately interwoven, so that a section of the stroma at any point shows many cross sections of hyphæ and seldom shows more than a small portion of any single filament. The cross partitions are very irregular, some filaments being only occasionally septate. The hyphæ are mostly simple, branching being only occasionally observed in the main mass of the stroma (figs. 12 and 13). Within the body of the insect and in the early stages of the stroma development, the branching is apparently abundant. The walls of the hyphæ are clear and hyaline, and are comparatively very thick, the lumen being small. The wall is usually about 1.5 micromillimeters thick, while the lumen is not much thicker, seldom being more than 1.94 micromillimeters in diameter. The cell contents are granular and somewhat vacuolate.

Dissemination of spores of mealy wing Aschersonia.—The distribution of Aschersonia sporules is a question of considerable importance, from an economic standpoint. The sporules are gelatinous, and are held together, so that the wind, which is the most common agent of fungous spore distribution, has no effect. The spore masses when wetted swell up and the exterior spores are gradually freed. It thus seems quite probable that rains and dews are agents of distribution, the spores being gradually loosened and washed to lower leaves, on which other

larvæ occur and may become infected. This is, without much doubt, one of the agents of distribution, but how far it is active has not yet been determined. Somewhat opposed to this method of distribution is the fact that the Aschersonia is always on the lower surface of the leaf, where it is difficult for rain and moisture to reach it. Should a drop reach the lower surface and thus become filled with the Aschersonia sporules, it would, in falling, naturally strike the upper surface of the leaf below, where none of the insects are located, and from this would probably be deflected and fall to the ground. On the other hand, if the Aschersonia were exposed to the full force of the rain, one heavy rainfall would serve to remove practically every sporule from the perithecia, and would probably dislodge the majority of the pustules, as their adherence to the leaf is very slight after the death of the insect. It may be that in their position under the leaf a sufficient quantity of the rain reaches them to serve the purpose of distributing the sporules.

The young larvæ of the mealy wing move about freely, but do not usually go from one leaf to another, all stages being passed on the leaf where the eggs are laid. Where Aschersonia pustules occur on this leaf the larvæ may become infected by actual contact with the spores, but infection seldom takes place in this way, as the eggs are usually deposited on new leaves, where no old larvæ, and consequently no Aschersonia, occur. After an Aschersonia pustule develops on such a leaf, other young larvæ on the same leaf may become infected by actual contact, but this is surely only occasionally the case and can not be considered of primary importance.

Certain observations have suggested to the writer that ants may be another medium of distribution, and possibly the primary one. These insects are frequently very abundant on leaves where the mealy-wing larvæ and pupæ occur. It is known to be a very common habit for ants to visit honeydew-secreting insects to feed on the honeydew. The bright color of the mucilaginous mass of sporules might attract the ants to feed or attempt to feed on them. In this way the sporules adhering to their mouth parts and limbs may be carried to the larvæ, to which the ants go for honeydew. In feeding on the honeydew as it is exuded they would probably leave in it a few sporules, which would germinate and penetrate the insect. Sufficient evidence has not yet been accumulated to justify the conclusion that this is really the case, but it is quite probable. The writer has frequently observed ants around the sporule masses, and they may have been eating the sporules or the mucilaginous matrix in which they are embedded. In either case they could not fail to carry away numerous sporules. The bright color of the sporule masses would suggest that the attractive coloration may serve some special purpose, and the writer is inclined to believe it will be found that some insect visitor carries the sporules. Gnats and flies are also frequently seen around leaves where the mealy wing occurs, and these

also may have something to do in spreading the sporules. Ants or other insects would serve to spread the Aschersonia sporules to other trees, possibly at some distance, while rain and dew could only spread them to closely adjoining trees. Conclusive light may be thrown on the means of dissemination, however, by further study of some of the points in the life history of the fungus which yet remain to be determined.

Methods of introducing mealy wing Aschersonia into orange groves.—Several experiments have been made with a view of finding artificial means of spreading the Aschersonia, the work being carried on in groves in which the fungus had not yet appeared. In these experiments the sporules were thoroughly mixed with water, and the mixture applied with a common atomizer on leaves harboring mealy-wing larvæ. No results, however, have as yet been obtained from experiments of this kind.

Orange branches containing Aschersonia pustules have several times been cut off and hung over branches infested with mealy-wing larvæ in groves where Aschersonia did not occur. In this way it was thought the sporules would be washed down by rain and the larvæ become infected. This method of infection has mostly proven ineffective, the fungus having appeared only in one case.

Probably the most satisfactory method by which Aschersonia can be introduced into groves where it does not occur is to transplant into them small orange trees which are infested with the mealy-wing larvæ parasitized by Aschersonia. Several experiments of this kind have resulted satisfactorily, and it is believed that the method may usually be relied upon, as the normal development of the mealy-wing larvæ and Aschersonia will be in no way interfered with. The young trees should be planted if possible in such a way that the leaves will mingle with those of the tree on which the uninfected larvæ occur. In case this can not be accomplished by planting the young tree in the ground, it is best to plant it in a box, which can be elevated to the position desired. In this case the young tree will require to be watered regularly until the Aschersonia has spread to the other tree. The time of transplanting the young trees is apparently of little importance, as the natural development of the insect and the fungus is not interfered with by this method. Young trees infested with Aschersonia can be easily packed and shipped to any part of the United States without injury to the trees or to the Aschersonia. In shipping trees of this kind either the tops should be wrapped in canvas or the trees should be inclosed in a light, close box. This precaution is necessary in order to prevent the introduction of the mealy wing into uninfected groves, and also to keep the Aschersonia pustules from being knocked off in transit. This would seem to be a feasible and practicable method of introducing the Aschersonia into groves affected with sooty mold following the mealy wing.

In groves affected with the sooty mold at Ocala, Orlando, Evinston,

and Ormond no sign of this fungus has yet been found. Probably many groves in the State where sooty mold follows the mealy wing still remain free from this friendly fungus.

Extensive field observations indicate that Aschersonia will prove a valuable aid in keeping the mealy wing in check and thus controlling the sooty mold. In the town of Gainesville, where the sooty mold has been very abundant and destructive for a number of years, it is generally acknowledged that the trees are gradually recovering, and this is probably to be attributed to the presence of Aschersonia, which is very abundant. On many trees it was difficult to find a living larva or pupa of the mealy wing, and in such cases the leaves were thickly dotted over with the pustules of Aschersonia.

At Panasoffkee, where sooty mold following the mealy wing has been very abundant for a number of years, Aschersonia appeared in 1892 and spread rapidly throughout the sooty mold infected section. Since the appearance of the Aschersonia the trees have gradually recovered, and some idea of the improvement can be formed from the fact that for several years previous to the introduction of Aschersonia the mold was so abundant that practically every fruit had to be washed before shipping, while last season (the winter of 1894–95) it was thought that none of the fruits would require washing.[1]

BROWN MEALY WING FUNGUS.

A second fungus parasitic on the larva and pupa of the mealy wing (*Aleyrodes citri*) was discovered by the writer in March, 1896, in the orange grove of Mr. J. H. Viser, at Manatee, Fla. This fungus forms seal brown pustules over the insects and ultimately entirely conceals them (fig. 27). One may easily raise a pustule (stroma) from the leaf and observe the insect which it conceals. The pustules formed over the larval or pupal scales are round or slightly elliptical and compressed hemispherical. In color and shape they resemble very much the Florida red scale (*Aspidiotus ficus*), and may be mistaken for this insect unless critically observed. A thorough study of this fungus has been made at several seasons of the year, but thus far no trace of fructification has been found, and it has therefore been impossible to determine its relationships. In describing the fungus to orange growers the writer has referred to it as the brown mealy wing or Aleyrodes fungus, and as this name is descriptive and serves to distinguish it from any other mealy wing fungus yet known, its use as a common name will probably not lead to confusion.

In March, 1896, when the brown mealy wing fungus was first discovered, it was found to be abundant over a large portion of the Viser grove of 5 acres. Many trees, however, did not contain a trace of it. A very careful search was made at this time in adjoining groves and

[1] Mr. H. B. Stevens, of Citra, Fla., manager of the Idlewild Grove at Panasoffkee, vouches for the above statement.

other groves in this vicinity, but no trace of the fungus could be found. Apparently it was limited to the Viser grove,[1] and had not yet spread all over this. At this time the grove was in very bad condition; scores of living larvæ of the mealy wing could be found on almost every leaf in it and the sooty mold was very abundant. In December, 1896, the grove was again carefully examined by the writer, and the fungus found to have spread with surprising rapidity. At this time it was difficult to find living specimens of the mealy wing anywhere in the grove, but in March millions of them could have been found on every tree. The fruit, which for several years previous had been very black with the sooty mold, was examined by the writer after it was picked and was found to be bright and entirely free from the fungus, and therefore required no washing. The sooty mold had been washed off the leaves to a considerable extent and the trees made a much better appearance. The new growth, which had formed during the latter part of the summer, remained bright and almost entirely uninfected with the mealy wing, while under the former conditions the numerous larvæ from the fall brood of the mealy wing would have been almost wholly on this new growth, and by this time would have become covered with the sooty mold. The same growth in other groves in the vicinity infected with the mealy wing was found to be abundantly infested with the larvæ and covered with sooty mold. The mealy wing Aschersonia was also present in the grove and abundant on some trees. The spread of the brown fungus, however, was so much more rapid and thorough that the Aschersonia played but a small part in comparison. The Viser grove had not been sprayed or otherwise treated for scale insects during the year, as it was the intention of the owner to fully test the efficacy of the parasitic fungi. Some of the orange growers of Manatee carefully watched the action of the fungi in this grove during the season, and were unanimous in the opinion that much aid may be expected from them.

Development of the brown mealy wing fungus.—The larvæ and pupæ of the brown mealy wing appear to be equally subject to infection in any stage of their development. The hyphæ develop in the body of the insect, burst out around the edges of the scale, and gradually grow up over it. In an early stage they form a brown, compact layer around the edge of the larva, as illustrated in figs. 28 and 29. As the fungus develops the hyphæ entirely cover the larval scale, forming a dense, hard, and smooth stroma (fig. 30). The mature stroma is compressed hemispherical, frequently having a slight depression in the apex over the center of the insect, where the hyphæ come together as they spread from the edges of the scale in their development. The size varies greatly, according to the stage of development of the insect

[1]The Viser grove is composed of seedling orange trees about fifteen years old. So far as could be learned, no trees from other localities have recently been set in this or any adjoining groves.

attacked. In very young larvæ it is from $\frac{1}{4}$ to $\frac{1}{2}$ a millimeter in diameter. In mature larvæ and pupæ it frequently reaches 2 millimeters in diameter. The thickness, or height, also varies in like manner, specimens on mature larvæ or pupæ being usually from 175 to 260 μ, while those on young larvæ are much thinner. The size of the stroma is frequently a somewhat confusing character, as on some leaves all the stroma are small, on others all are large, while on still others all sizes may be found. This is due to the stage of development in which the insects are at the time the fungus is introduced on the leaf. The stroma is commonly seal brown, with a shade of chestnut, but becomes slightly darker with age. It adheres closely to the leaf, but no indication has been found that the hyphæ penetrate the latter.

The hyphæ, which make up the body of the stroma, are light brown, very tortuous, and but slightly branched. Those in the body of the insect are of similar character, but a much darker brown.

From the base of the stroma a ground mycelium, or hypothallus, spreads out in all directions on the surface of the leaf, forming a compact membrane near the stroma, but becoming gradually dispersed into separate filaments. In a number of cases the writer has observed these filaments spreading about 13 millimeters (one-half inch) in each direction. All observations which the writer has been able to make indicate that these hyphæ of the hypothallus, which spread out on the surface of the leaf, have the faculty of infecting other mealy wing larvæ with which they come in contact. Indeed, this character is of great importance, as it evidently accounts for the very thorough action and rapid spread of the fungus. When once the fungus is introduced on a leaf, these hyphæ, spreading out in all directions, rapidly infect the other larvæ on the leaf, and kill all as far as they extend. As no reproductive organs have been found, it seems probable that the spread of the fungus is effected through fragments of the mycelium which are carried by wind or birds. The hyphæ of the hypothallus are colorless, sparingly branched, mostly continuous, having only an occasional septa, and are from 5 to 7 μ in diameter. In some places in the hypothallus, where the hyphæ are apparently somewhat amassed and knotted, they become light brown, similar in color to the isolated hyphæ of the stroma (fig. 31). The hypothallus membrane adheres only slightly to the surface of the leaf and is very easily removed. Old leaves on which the larvæ have been dead for some time, and on which the fungus has been exposed for an extended period to the action of rains, etc., clearly show the slight damage to the leaf caused by this fungus. Leaves which were observed in March, 1896, to be badly infected with the fungus, were found in December of the same year to show only the remains of the pustules, the hypothallus having been entirely washed away. That the fungus does some damage to the tree can not be denied, but this is clearly a secondary effect. The fact that it occurs only on the under surfaces of the leaves, where the larvæ and pupæ of the mealy wing

are located, never occurring unless these are present, and disappearing when all are killed, clearly indicates its parasitic nature. It appears to be an obligate parasite in the early stages of development, but continues to develop for a considerable period after the death of the insect, as described above in the case of *Aschersonia aleyrodis*, and thus in its later stages becomes a facultative saprophyte.

Methods of introducing the brown mealy wing fungus into orange groves.—During the summer of 1896 the brown mealy wing fungus spread by the natural means of dissemination to other groves in the vicinity of Manatee, and at the present time many groves infested with the mealy wing contain an abundance of the fungus. It is, however, still limited to a radius of about 2 miles from the Viser grove. Attempts have been made to spread the fungus artificially, and in some cases with success. In one case leaves containing infected larvæ were simply tied on a tree infected with the mealy wing. An examination a few months later revealed the presence of the fungus on an adjoining tree. While not on the tree on which the affected leaves were tied, the infection would, nevertheless, appear to have come from these leaves, as no other groves near contained the fungus. In two cases which have come under the observation of the writer the fungus has been introduced by planting in boxes small nursery trees harboring infected mealy wing larvæ, and placing these in such a position that the leaves of the young trees mingled with those of trees badly infested with the mealy wing larvæ on which the fungus did not occur. An examination several months later showed that the fungus had spread onto the adjoining trees, which were before free. The writer has also learned of several other cases where the fungus was introduced into orange groves in this way. This method, which is not difficult or costly, allows the natural methods of dissemination to act, and it would seem to be almost sure of success. In many cases the young trees may be simply planted in the earth beside the trees which it is desired to infect, planting them so that the leaves of the two trees will mingle. This will avoid the necessity of watering.

As in the case of the mealy wing Aschersonia, the time of transplanting the young trees containing the parasitic larvæ is probably not important, as the natural development of the insect and fungus is not interrupted. What is said on page 26 relative to packing and shipping young trees containing Aschersonia applies equally in the case of the brown mealy wing fungus.

OTHER ASCHERSONIAS INFECTING SCALE INSECTS.

An Aschersonia differing from that occurring on the mealy wing has been found to infest the white or wax scale (*Ceroplastes floridensis* Comstock). Specimens of this fungus have been found in several places in Florida, but in greatest abundance at Citra. This Aschersonia is

probably to be referred to *A. turbinata* Berk., which is described from specimens collected in St. Domingo on *Corynes sarcoidis*. Specimens of *A. turbinata* on orange leaves from Citra and on some plant not belonging to the citrous family (*Psidium?*) from Nicaragua were distributed by Mr. Ellis in 1888.[1] In Florida the writer found *A. turbinata* infecting wax scales on common orange (*Citrus aurantium*) leaves, mandarin orange (*C. nobilis*) leaves and stems, and on hackberry (*Celtis occidentalis*) leaves. The scale is evidently subject to attack at any stage of life. The stromata are cream-colored, cylindrical or turbinate, and about 1 millimeter in diameter and 1 to 2 millimeters high (fig. 22). They are usually simple, but are not infrequently from 2 to 4 fasciculate. The apex of the stroma is excavated, forming a shallow cavity, into which the perithecia open and discharge the sporules (fig. 23). The sporules in mass are orange-rufus or cinnamon, fading to tawny (fig. 24).

The wax scale, which is invariably followed by sooty mold, is not usually very serious, seldom requiring special treatment. The fact that it does little damage is due largely, the writer thinks, to the ravages of its fungous enemy *A. turbinata*. In 1894 an instance came under the writer's observation which clearly demonstrated the effectiveness of the fungus, at least under certain circumstances. In the summer of the year mentioned the wax scale and sooty mold became very abundant in a portion of the Crescent Grove at Citra, causing the owners much alarm. While preparations were being made to spray for the malady the manager found a few pustules of the Aschersonia, and it was decided to dispense with the spraying and test the action of the fungus. The Aschersonia spread rapidly and almost entirely destroyed the scale. In September, when the fungus was first noticed, the sooty mold was at its height, the trees being very black from the disease. Two months later (November 2) the writer examined the trees and could find only a few living scales, while the Aschersonia was very abundant. The sooty mold had also largely disappeared, having been washed off by the rains.

A third Aschersonia, differing specifically from both of the above, has been found to infest the turtle-back scale (*Lecanium hesperidum* L.). The clay-colored stroma grows up over the scale, as in the case of the mealy wing Aschersonia, forming a hemispherical pustule from 1½ to 2½ millimeters in diameter, and usually about 1 millimeter high when mature. The sporule masses, which are mostly rufus in color, are rather smaller and less conspicuous than in the mealy wing Aschersonia. This fungus was first observed at Myers, Fla., June 12, 1895, on scale insects infesting the grape fruit and orange. It was quite abundant, and seemed to be rapidly destroying the colony of scales where it occurred.

Two other Aschersonias, probably differing from those above described, have been found on honeydew-secreting scale insects infesting

[1] Ellis, J. B., and Everhart, B. M., North American Fungi, No. 2172.

the red bay (*Persea carolinensis*) and the coontie plant (*Zamia integrifolia*). These give further evidence of the destructiveness of Aschersonia to scale insects, but do not otherwise concern us at present.[1]

SUMMARY.

The following is a summary of the most important points in the bulletin:

(1) Sooty mold of the orange is very abundant and destructive in Florida, Louisiana, and California, and probably throughout the orange regions of the world. In Florida alone it causes an annual loss of nearly $50,000.

(2) Sooty mold in Florida is evidently caused by several black fungi, which are to be referred principally to *Meliola penzigi* and *M. camelliæ*. The mycelia of these fungi anastomose abundantly, ultimately forming a dense membrane, which frequently covers the entire upper surface of the leaves. Several forms of reproductive bodies are produced in great abundance, and these are distributed principally by the wind.

(3) Sooty mold is probably a true saprophytic fungus, deriving its nourishment wholly from the honeydew secreted by certain insect pests which the fungus invariably follows. Careful search has been made for sweet exudations from the orange tree, similar to that observed by Guinier, which might serve as nutrition for the sooty mold, but no indication of such exudations have been found.

(4) Sooty mold occurs on numerous wild and cultivated plants other than the orange.

(5) The effect of sooty mold is very serious. Frequently growth is entirely stopped by its checking the phytosyntax, or assimilation. Fruit affected with this disease does not ripen normally and is of inferior size and quality; moreover, when covered with this fungus, the oranges must be washed before marketing, and this injures their keeping qualities. To remove the mold, wash the fruit in barrels with sawdust and water or scrub by hand.

(6) The sooty mold follows a number of insects infesting the orange, but becomes serious in Florida only when it follows attacks of the mealy wing, or white fly (*Aleyrodes citri*). This orange pest secretes honeydew in the adult larval and pupal stages.

(7) Experiments have been made with numerous promising sprays in various strengths and combinations. Resin wash, resin compound, pyrethro kerosene emulsion, and resin wash with tobacco decoction proved to be very effective. The methods of preparing resin wash and resin compound have been considerably simplified and they are recommended as effective and practical remedies for the sooty mold when following the mealy wing. The resin washes do not injure the tree or fruit unless used much stronger than here recommended.

[1] The writer is preparing a paper on the fungous parasites of scale insects, in which these Aschersonia will be fully described.

(8) Treatments for sooty mold should be made during the winter (from the first of December to the first of March), in May, or during August and the early part of September. Two or three sprayings should be made during the winter and one in May. Another application may be made during the August period if the sooty mold is found to be spreading onto the fruit. This period is in the rainy season, and the spray is liable to be washed off by the frequent rains which occur.

(9) In spraying for sooty mold it is of primary importance to wet the under surface of the leaves. In order to do this it is necessary for the operator to get under the tree and spray outward. Preparatory to spraying it is a good practice to trim out the tree from within. An abundance of spray must be used, as every leaf must be wetted thoroughly on the lower surface.

(10) Systematically collecting and burning all water sprouts at the beginning of each spraying period has been found to be a good practice.

(11) Fumigation with hydrocyanic acid gas by the use of tents covering the trees also gave very excellent results in the treatment of the malady. The proper time to fumigate is in the winter, between December and the first of March.

(12) Several entomogenous fungi have been discovered, which will probably prove of great aid in holding in check the sooty mold and the pests which it follows.

(13) *Aschersonia aleyrodis* n. sp., an undescribed fungus, which is parasitic on the larva and pupa of the mealy wing, has been found to be very abundant in many groves infested with sooty mold following this insect. Only the larva and pupa of the mealy wing are subject to attack, the infection taking place most commonly in the young larvæ. The fungus develops in the interior of the larva and later bursts out around the edges. At this stage of the infection the larva dies, but the fungus continues its development, growing up over the dead larva and finally entirely surrounding and concealing it.

(14) The sporules of the mealy wing Aschersonia are very minute and are produced in great numbers. They are mucilaginous and form bright coral red masses. They are probably partially distributed by the action of rains, but it is thought that ants and insects attracted to the sporule masses by their bright color may carry some of the sporules to uninfected mealy wing larvæ or pupæ when they go to feed on the honeydew.

(15) Artificial infection experiments, consisting in spraying the Aschersonia sporules mixed in water on leaves infested with mealy wing larvæ, and by hanging branches containing Aschersonia pustules so that the rain would wash the spores down on the uninfected mealy wing larvæ, have thus far failed to give satisfactory results. Apparently the best way to introduce the friendly Aschersonia into groves where it does not occur is to transplant into it young trees harboring mealy wing larvæ infested with Aschersonia. In sending such trees by

express or freight they should be wrapped throughout with canvas or placed in a tight box to prevent the introduction of the mealy wing into uninfected groves.

(16) A second fungus parasitic on the mealy wing has recently been discovered at Manatee, Fla., which from its color is termed the brown mealy wing fungus. This gives evidence of being much more effective in its action than *Aschersonia aleyrodis*. No fructification having as yet been found, the relationships of the fungus can not be given. In the grove where the fungus was first discovered its spread was so rapid during the past summer that the mealy wing was almost eradicated.

(17) The brown mealy wing fungus attacks the mealy wing larvæ and pupæ in any stage of development. In an early stage it bursts out around the edge of the insect scale, forming a dark brown circle. It continues to develop after the death of the insect, ultimately entirely concealing the latter, and forming hard, smooth, seal brown pustules from ½ to 2 millimeters in diameter. A silvery white mycelium spreads out from each pustule or stroma in all directions on the surface of the leaf, frequently extending about 13 millimeters. This mycelium infests other larvæ with which it comes in contact.

(18) The brown mealy wing fungus has been introduced into orange groves infested with the mealy wing by hanging branches harboring larvæ infected with the fungus in the trees, and by transplanting young trees, as in the case of Aschersonia. The latter method is recommended as the surest of success. Care should be exercised in shipping infested trees to carefully box them in order to protect the fungus and avoid introducing the mealy wing into other sections. The writer believes that it may safely be assumed that the spread of *Aschersonia aleyrodis* and the brown mealy wing fungus will ultimately materially check the ravages of the mealy wing and sooty mold.

(19) It has been found that *Aschersonia turbinata* is parasitic on the wax scale (*Ceroplastes floridensis*), also a honeydew-secreting insect which the sooty mold follows. One instance is cited where a severe attack of wax scale was checked by *Aschersonia turbinata*.

(20) An Aschersonia differing from either of the above has been discovered to be parasitic on the turtle-back scale (*Lecanium hesperidum*).

(21) The entomogenous nature of this group of fungi is here pointed out for the first time. In the early stages of development they are apparently obligate parasites, but in their later stages may be what De Bary has termed facultative saprophytes.

DESCRIPTION OF PLATE I.

FIG. 1.—Sooty mold of the orange following the mealy wing (*Aleyrodes citri*). The sooty mold shows as a black covering on the fruit and upper surface of the old leaves. The larval scales of the mealy wing are shown on the lower surface of the leaves. At a the fresh uninfected new growth is shown.

FIG. 2.—An orange leaf showing the lower surface covered with numerous pustules of *Aschersonia aleyrodis* growing parasitically on the larvæ of the mealy wing.

Puttler Collotype. D. G. Passmore.

SOOTY MOLD OF THE ORANGE, FOLLOWING THE MEALY WING OR WHITE FLY (ALEYRODES CITRI).

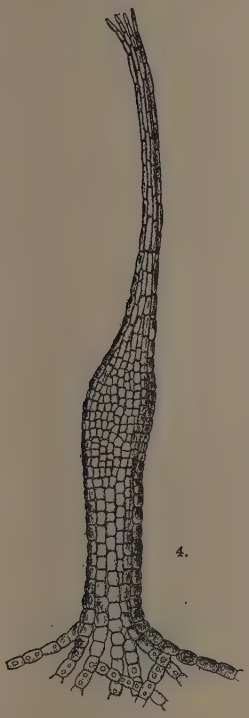
DESCRIPTION OF PLATE II.

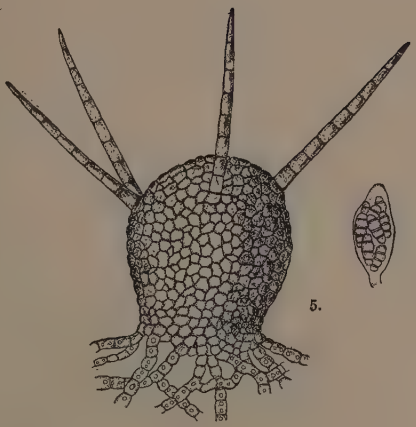
Meliola camelliæ.

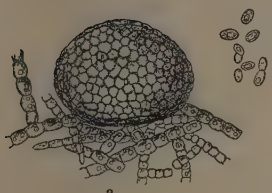
FIG. 3.—Pycnidia conceptacle, with spores on right, × 160 diameters.
FIG. 4.—Stylospore conceptacle, × 160 diameters.
FIG. 5.—Perithecium, × 160 diameters, with ascus and ascospores on the right, × 250 diameters.
FIG. 6.—Mycelium of the sooty mold, × 175 diameters.
FIG. 7.—Conidia of the simplest form, × 200 diameters.

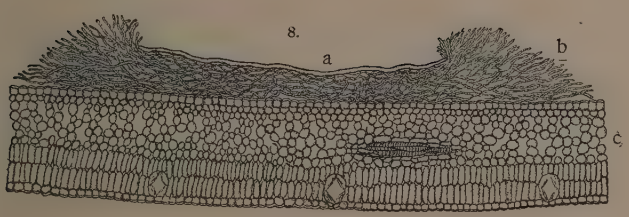
Aschersonia aleyrodis.

FIG. 8.—Section through a scale of *Aleyrodes citri* attacked by *Aschersonia aleyrodis*, × about 80 diameters; a, remnant of insect scale; b, mycelium of Aschersonia bursting out around the edge of the scale; c, orange leaf in cross section. (From drawings by the author.)









SOOTY MOLD OF THE ORANGE AND FUNGOUS PARASITE OF WHITE FLY.

DESCRIPTION OF PLATE III.

Meliola camelliæ.

FIG. 9.—Stylospore conceptacles of *Meliola camelliæ;* a, b, and c × 170 diameters; d × 75 diameters.

Aschersonia aleyrodis.

FIG. 10.—Outline of section through a pustule in median stage of development, × 25 diameters; a, remnant of insect scale; b, stroma; s, mass of sporules.

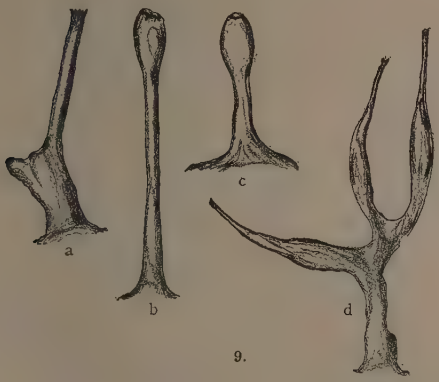
FIG. 11.—Outline of a section through a mature pustule, × 25 diameters; a, remnant of insect scale; b, stroma; p, perithecia.

FIGS. 12 and 13.—Mycelium forming the stroma. × 150 diameters.

FIG. 14.—Sporules, × 750 diameters.

FIG. 15.—Hymenium, showing basidia, paraphyses, and sporules, × 150 diameters.

FIG. 16.—The ends of three basidia, with sporules attached, × 750 diameters. (Fig. 11 from a drawing by Mrs. H. J. Webber, all other figures from drawings by the author.)



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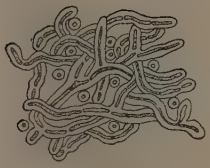

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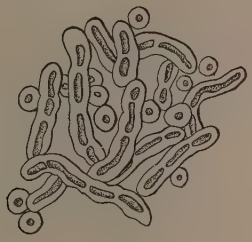

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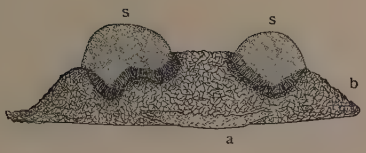

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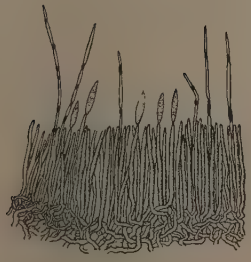

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11.

SOOTY MOLD OF THE ORANGE AND FUNGOUS PARASITE OF WHITE FLY.

DESCRIPTION OF PLATE IV.

Aschersonia aleyrodis.

FIG. 17.—Healthy larva of mealy wing (*Aleyrodes citri*), × 15 diameters.

FIG. 18.—Larva of mealy wing infected with *Aschersonia aleyrodis* in early stage of development; a, opaque, light-colored areas, in which the fungus develops particularly abundant, × 15 diameters. (The death of the insect takes place at about this stage.)

FIG. 19.—Later stage of development. The hyphæ are shown bursting out around the edge of the larva, × 15 diameters.

FIG. 20.—A still later stage of development, showing the first fructification forming in a circle around the edge of the old larval scale, × 15 diameters.

FIG. 21.—Stroma in median stage of development, showing the erumpent, confluent masses of sporules forming a circle near the margin, × 15 diameters. (Fig. 10 is from a pustule in the same stage of development.)

FIG. 22.—Stroma, showing hypothallus and erumpent sporule masses as occasonally found when protected from rain and dew, × 15 diameters.

FIG. 23.—Mature stroma showing openings to perithecia, × 15 diameters. (Fig. 11 is from a pustule in the same stage of development.)

Aschersonia turbinata.

FIG. 24.—Sporules of *Aschersonia turbinata*, × 500 diameters.

FIG. 25.—Cross section of mature stroma showing the perithecia, × 20 diameters. (Drawn by Mrs. H. J. Webber, under the author's supervision.)

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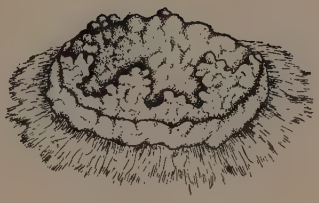

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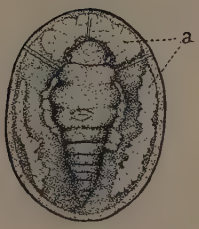

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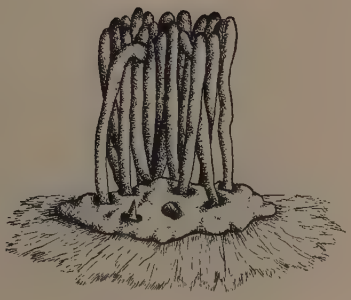

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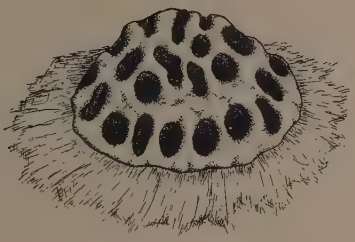

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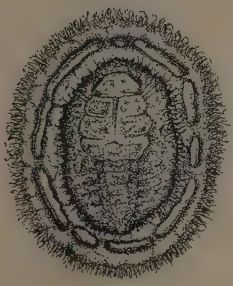

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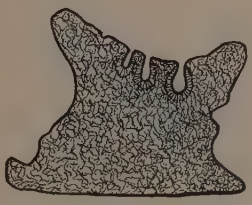

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ASCHERSONIA FUNGI OF WHITE FLY.

DESCRIPTION OF PLATE V.

Aschersonia turbinata.

FIG. 26.—Photograph of pustules on mandarin orange leaf, collected at Citra, Fla., November 2, 1894. (Natural size.)

Brown mealy wing fungus.

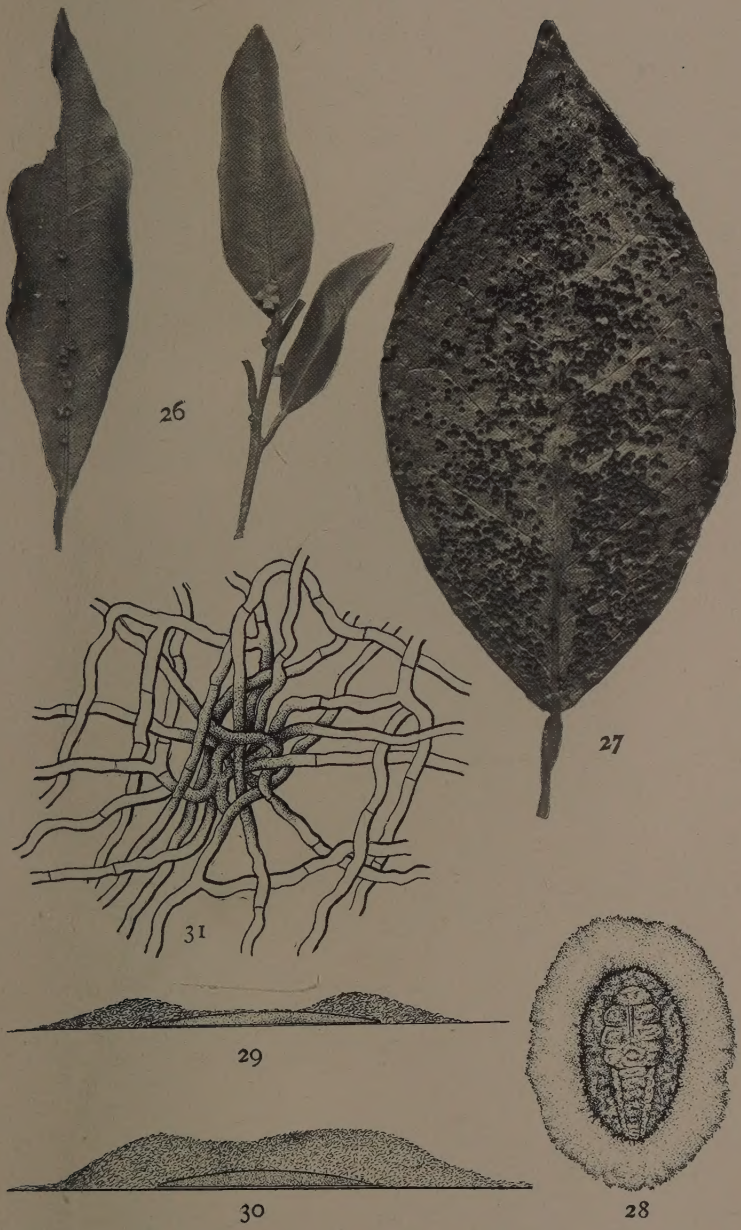
FIG. 27.—Photograph of leaf showing larvæ of *Aleyrodis citri*, parasitized by brown fungus; leaf collected at Manatee, Fla., December 24, 1896. (Natural size.)

FIG. 28.—Larva of *Aleyrodes citri* showing fungus in early stage of development, × 15 diameters.

FIG. 29.—Cross section of larva and stroma of fungus in stage represented in fig. 28, × 30 diameters.

FIG. 30.—Cross section of mature stroma of fungus showing remains of larval scale, × 30 diameters.

FIG. 31.—A portion of the hypothallus showing hyphæ, × 400 diameters. (Photographs by the author; drawings by Mrs. H. J. Webber, under the supervision of the author.)



BROWN MEALY-WING FUNGUS.